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Big Oak State Park; article on p. 4. Photo: Missouri Department of Natural Resources

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FROM THE EDITOR

This is the 36th volume of *Missouriensis*, the official technical publication of the Missouri Native Plant Society, and the third volume since the journal transitioned to an all-electronic format. As with the previous two online issues, individual articles and the full volume are freely available through the Society's website as open-source archival pdf files.

Several individuals were critical to the production of this issue, notably Cindy Pessoni of The Nature Conservancy, who continues to provide guidance and expertise on all aspects of editing, formatting, design and production; her contributions have been essential to the journal since the first online issue. Appreciation is also extended to reviewers who contributed their time and expertise to this volume: Paul McKenzie, U.S. Fish and Wildlife Service; Caleb Morse, University of Kansas; Mike Skinner, Missouri Department of Conservation (retired); Justin Thomas, NatureCITE; Gerould Wilhelm, Conservation Research Institute; and two anonymous reviewers. Thanks are also extended to Aaron Floden, Missouri Botanical Garden and George Yatskievych, University of Texas and former *Missouriensis* editor, for their help and input. Thanks also to Jerry Barnabee, the society's new webmaster, for his expertise and timeliness in getting this volume online with very short notice.

As this volume demonstrates, *Missouriensis* is broadly focused on articles that increase knowledge on all aspects of Missouri plants and ecosystems, including both non-flowering vascular plants and non-vascular plants such as bryophytes and lichens. We welcome submission of manuscripts for consideration for publication, and as always, comments and suggestions regarding the journal are welcome.

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Rhynchospora glomerata, new to Missouri, and an Updated Key to the Genus in the State

AARON FLODEN[1] AND ALAN E. BRANT[2]

ABSTRACT. — *Rhynchospora glomerata* is reported new to Missouri from 5 counties in the eastern Ozarks. A revised key to the 9 species of *Rhynchospora* in the flora is provided to aid identification.

Rhynchospora glomerata (L.) Vahl is a ubiquitous component of moist to wet habitats in the Southeastern U.S. where it is often syntopic with other *Rhynchospora* species, notably *R. capitellata* (Michx.) Vahl. The distribution of *R. glomerata* borders southern Missouri and it occurs in adjacent counties in Arkansas, although no collections have been documented for Missouri. Naczi and Moyer (2017) report *R. glomerata* from Kansas, and it is considered endangered in Illinois (IESPB 2015). Several Missouri botanists have expected that field studies or specimen analysis would eventually lead to the documentation of *R. glomerata* in Missouri.

During examination of specimens at MO, several *Rhynchospora* determined as *R. capitellata* were notably taller and had distinctly larger spikelets than typical plants of this species. Measurements of the spikelets (4.5–5.7 mm vs. 3.5–4 mm) and achenes (3.2–3.8 mm vs. 2–3 mm) of these specimens were well outside the range of *R. capitellata*. These were confirmed as *R. glomerata* using the Flora of North America *Rhynchospora* treatment (Kral 2002) and the recent revision of the *R. glomerata* species group (Naczi & Moyer 2017). Missouri specimens of *R. glomerata* are reported below.

> *Specimens examined*: **U.S.A. MISSOURI:** CARTER CO.: 5 miles south of Ellsinore on Hwy K, just south of New Hope – Waddell property; persistent wet area in pasture; associated with *Carex laevivaginata, C. lurida, C. oklahomensis, C. scoparia, C. suberecta, Schoenoplectus tabernaemontani, Juncus effusus, Glyceria striata, Agrimonia parviflora, Eupatorium perfoliatum*, 36° 51' 44"N, 90° 43' 32"W; 18 June 2005, *Walker s.n.* (MO). IRON CO.: Bluffs and slopes along Crane Pond Creek from old dam up to Forest Service land; sandstone substrate; cespitose or short rhizomatous spreading in open cracks of sandstone pavement along stream, wet, sandy alluvium; N1/2 NW1/4 sec. 3 T31N R4E; 30 June 1993, *Brant 2445* (MO). SHANNON CO.: The Nature Conservancy's Shut-In Mountain Fen, ca. 1 mile E of Highway H, open swampy calcareous fen; 27 Aug 1999, *Summers & Pelton 9412* (MO). STE GENEVIEVE CO.: Toe slopes and floodplain of Jonca Creek; moist to mesic, open, sandy alluvium along stream, rhizomatous;

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SE1/4 sec. 2 T36N R7E; 2 Aug 1993, *Brant 2548* (MO). WAYNE CO.: South tributary of Brushy Creek, 1 air mile south of county highway A, ca. 4 air miles west of Williamsville; ca. 1-acre high-quality fen with moderate gradient; 21 Sep 2002, *Vogt 521B* (MO). Coldwater Conservation Area, open perched fen above south branch of Hunter Creek; cespitose but forming dense patches in open fen, with *Juncus subcaudatus*, *Carex hystericina*, *C. atlantica* subsp. *capillacea*; 37° 15' 32"N 90° 24' 6"W; 31 August 2017, *Brant 8582* (MO). Streamhead fen-seep complex, south branch of Hunter Creek, open and shrub seeps, south-facing, cespitose but forming dense stands in open saturated fen with *Juncus canadensis*, *J. subcaudatus*, *Fuirena simplex*, *Rudbeckia fulgida*; 37° 15' 36"N 90° 24' 6"W; 6 September 2017, *Brant 8625.* (MO); ibid., 8 July 2017, *Brant 8471* (MO); ibid., 4 Aug 2017, *Brant 8498* (MO); ibid., 4 Aug 2017, *Brant 8500* (MO); ibid., 29 July 2017, *Brant 8480* (MO).

In Missouri, *Rhynchospora glomerata* occurs in five counties in the southeastern portion of the state in the Lower Ozarks and the St. Francois Mountains sections of the Ozarks. It is highly likely, given the similarities of *R. glomerata* and *R. capitellata* in the field, especially without comparison of their spikelets, that there remain overlooked occurrences of this species in the state. Documented populations are from fens, springheads, creek floodplains, and wet swales in sandy alluvium often underlain by limestone. There are fewer than 10 known populations of *R. glomerata* in 5 counties and it would rank as S2 (Imperiled) for Missouri, although fieldwork in adjacent counties in similar habitats will undoubtedly lead to the discovery of additional populations.

KEY TO MISSOURI *RHYNCHOSPORA*

Rhynchospora globularis and *R. recognita* are treated as separate species following Kral (2002).

1 Style simple or 2-fid only at apex; fruit tubercules stout and conic and longer than fruit body; plants typically robust.
  2 Perianth bristles (5-) 6, 11–14 mm long, subequal and longer than the mature fruits...***R. macrostachya***
  2 Perianth bristles usually 5 (3–6), 2–4 mm long, unequal and shorter than the mature fruits ....***R. corniculata***
1 Styles deeply divided into 2 stigmatic branches; fruit tubercles variable in shape and size; plants variable in size.
  3 Plants annual, caespitose; rhizomes absent; spikelets 3–7 mm long; fruit body 1.3–1.5 mm long; tubercle to 0.5 mm and distinctly flattened ..... ***R. scirpoides***
  3 Plants perennial, caespitose or rhizomatous; rhizomes absent or present; spikelet's 2.5–7.0 mm long; fruit body 1.2–2.8 mm long, tubercles 0.3–1.6 mm long and triangular to conical.
    4 Perianth bristles retrorsely barbellate, bristles surpassing middle of fruit body and typically longer than fruit; achenes ovoid to ellipsoid with prominent elongate achene tubercules more than half the achene body length.
      5 Leaf blades 0.2–0.4 mm wide, margins involute; clusters of spikelets ovoid.....***R. capillacea***
      5 Leaf blades 0.5–7 mm wide, flat; clusters of spikelets turbinate or hemispherical.
        6 Spikelets 3.5–4 (-5) mm long; fruits (2-) 2.5–3 mm long, obovoid, tubercle typically abruptly tapered; plants typically smaller ..... ***R. capitellata***

6 Spikelets 4.5–6.5 mm long; fruits 3–3.5 (-4) mm long, pyriform, tubercle typically stout and triangular; plants typically robust ..... ***R. glomerata***

4 Perianth bristles antrorsely barbellate or rarely smooth, bristles shorter than the body of the fruit, usually not reaching the midpoint; achenes rounded to ovoid with tubercles length less than half the achene body length.

7 Achenes 1.4–1.8 × 1.4 –1.7 mm, tubercules with prominent bony or crustaceous rim at its base..... ..... ***R. harveyi***

7 Achenes 1–1. 8 × 1.3–1.6 mm, tubercules without prominent rim at base.

8 Leaf blades typically 1.5–2.5 mm wide; achenes nearly round 1.3–1.5 × 1.3–1.5 mm ..... ***R. globularis***

8 Leaf blades typically 3–4.5 mm wide; achenes oblate, 1.3–1.8 × 1.3–1.6 mm ..... ***R. recognita***

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Bryophytes of Big Oak Tree State Park, Mississippi County, Missouri

JOHN J. ATWOOD[1] AND NELS J. HOLMBERG[2]

ABSTRACT. — An inventory of the bryophytes of Big Oak Tree State Park in southeastern Missouri documented 70 species (60 mosses, 9 liverworts, and 1 hornwort). About half of these species are new distribution records for Mississippi County or are newly documented for the Mississippi Lowlands Natural Division in Missouri. *Fissidens hallianus* is newly documented for the state. Four mosses (*Gemmabryum klinggraeffii* [S1], *Pylaisiadelpha tenuirostris* [S2], *Rosulabryum flaccidum* [S2], and *Trematodon longicollis* [S2]) and a hornwort (*Phaeoceros oreganus* [S1]), are of conservation concern in Missouri.

INTRODUCTION

The Mississippi alluvial embayment extends from southeastern Missouri to the Gulf of Mexico along the floodplain of the Mississippi River. The area is comprised mostly of agricultural fields and wet irrigation ditches, swampy lowland forests, as well as sand prairies and savannas. At the northern edge of this broad basin is Big Oak Tree State Park in Mississippi County (Figure 1). It contains remnants of dense bottomland forest that covered Missouri's southeastern-most counties from pre-settlement until the early 20th century. By the 1920s, more than half of this forest had been logged, with additional logging, expanded agricultural interests, and government assisted drainage projects continuing deforestation through the proceeding decades (Doolen 1984; Korte and Fredrickson 1977). By the 1930s, statewide public outcry about the disappearing forest resulted in a campaign to save a particularly large burr oak (*Quercus macrocarpa* Michx.), as well as 80 acres of surrounding old growth forest. Donations from citizens and local school children helped the state purchase the land, along with an additional 920 acres of adjoining bottomland forest. In 1938, Big Oak Tree State Park was established, with most of the park later designated a state Natural Area in 1977. The park was also designated a National Natural Landmark in 1986. Big Oak Tree State Park is known for its state champion trees, such as persimmon (*Diospyros virginiana* L.), as well as its massive remnants of former state champions like burr oak.

The park contains a swamp community that extends diagonally through the center of the park, from the southeastern boundary to roughly the drainage channel leading to St. John's Diversion Ditch; a shrub swamp community that occupies the southwestern margin of the man-made Big Oak Lake; a wet bottomland forest that surrounds the swamp in the remaining southern

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and central portions; and a wet-mesic bottomland forest that occupies the remaining eastern and northernmost sections of the park. Big Oak Tree's vascular plant flora contains more than 230 species (Doolen 1984), several of which have affinities with the Atlantic and Gulf Coastal Plains, including *Trepocarpus aethusae* Nutt. *ex* DC. Few bryophytes have been reported from the park. Gier (1955) documented nine mosses and four liverworts from Mississippi County based on specimens collected at Big Oak Tree State Park. Doolen (1984) added six additional mosses, as well as three liverworts and a hornwort, bringing the total number of bryophytes reported from the park to 23 species. An additional 12 bryophyte species have since been collected from Big Oak Tree State Park, based on herbarium specimens in the Consortium of North America Bryophyte Herbaria's online database (CNABH 2015). These specimens, however, have not been reported in the literature. Most of these specimens are deposited in the herbarium at the Missouri Botanical Garden (MO), while a few are located at the New York Botanical Garden's herbarium (NY).

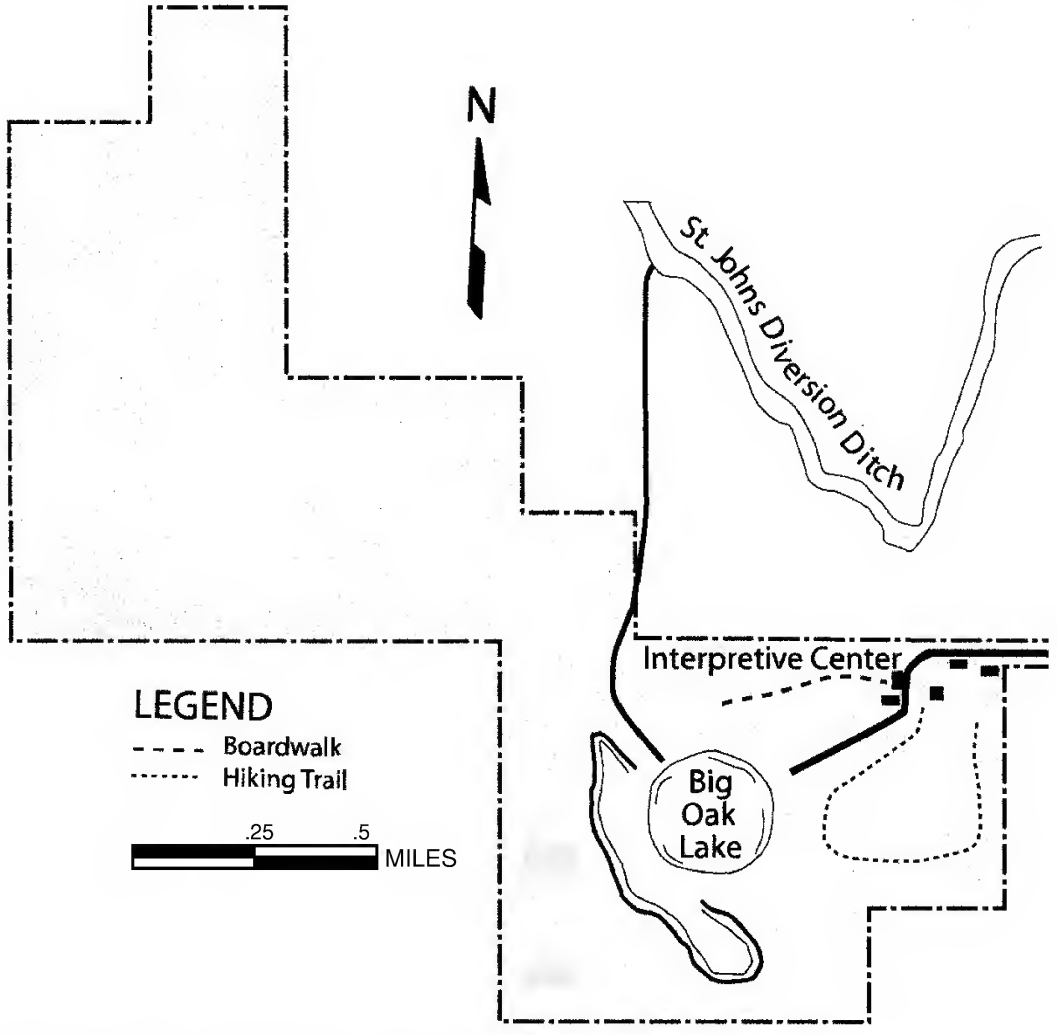

Figure 1. Boundary map of Big Oak Tree State Park.

The purpose of this survey was to document the bryophyte diversity within Big Oak Tree State Park and to establish a reference list of taxa for other floristic evaluations in the Mississippi Lowlands Natural Division (Thom & Wilson 1980). Big Oak Tree State Park is the only Missouri state park in the Mississippi Lowlands, and has the only *Taxodium* swamp within the state parks system. Bryophytes have historically been under-collected in the Mississippi Lowlands. Significantly fewer species have been reported from this natural division than any other natural division in the state (Atwood 2014; Darigo 2015).

METHODS

A bryophyte survey of Big Oak Tree State Park was conducted from December 2015 to March 2017. Seven collecting excursions were made within the park's boundaries. Most of these excursions began at the Boardwalk or trailhead of the Hiking Trail (Bottomland Trail), except for one excursion that accessed the northwest corner of the park through private property. Bryophytes were collected into individual paper envelopes, with their habitat and locality recorded. Representative voucher specimens from the park are deposited in the herbarium at Missouri Botanical Garden (MO). The complete habitat and locality data can be accessed through the Garden's online herbarium database (Tropicos: http://www.tropicos.org). Additional specimens previously collected at Big Oak Tree State Park and deposited at MO and NY were also re-examined. Historical specimens are cited in the checklist only when the species was not re-collected during this study, or for those species whose determinations have changed. The following checklist is arranged alphabetically by genus, followed by species and infra-specific taxa. Classification of the mosses follows *Flora of North America* (2007, 2014) except for deviations from recent publications. Classification of liverworts follows Stotler and Crandall-Stotler (2017), and hornworts follows Stotler and Crandall-Stotler (2005), with some deviations. Relevant literature citations are provided for some taxa.

RESULTS & DISCUSSION

A total of 349 bryophyte collections were made from Big Oak Tree State Park during the survey, including 286 mosses, 62 liverworts, and 1 hornwort. From these, 60 moss taxa, nine liverwort taxa, and one hornwort were determined. Figure 2 depicts the total number of bryophytes collected at the park in the order in which newly documented taxa were recorded. The cumulative taxonomic diversity suggests that the majority of the bryoflora at Big Oak Tree State Park has been documented, and that the probability of adding many new taxa to the park with further collecting is low. However, Big Oak Tree State Park historical specimens of three species — *Frullania eboracensis* subsp. *eboracensis*, *Gemmabryum dichotomum* and *Orthotrichum diaphanum* — were located at MO, but not found during this survey. Furthermore, a report of the hornwort *Notothylas orbicularis* from the park could not be substantiated during the survey. These four species are discussed further in the checklist and bring the total number of bryophytes in the park to 74 taxa.

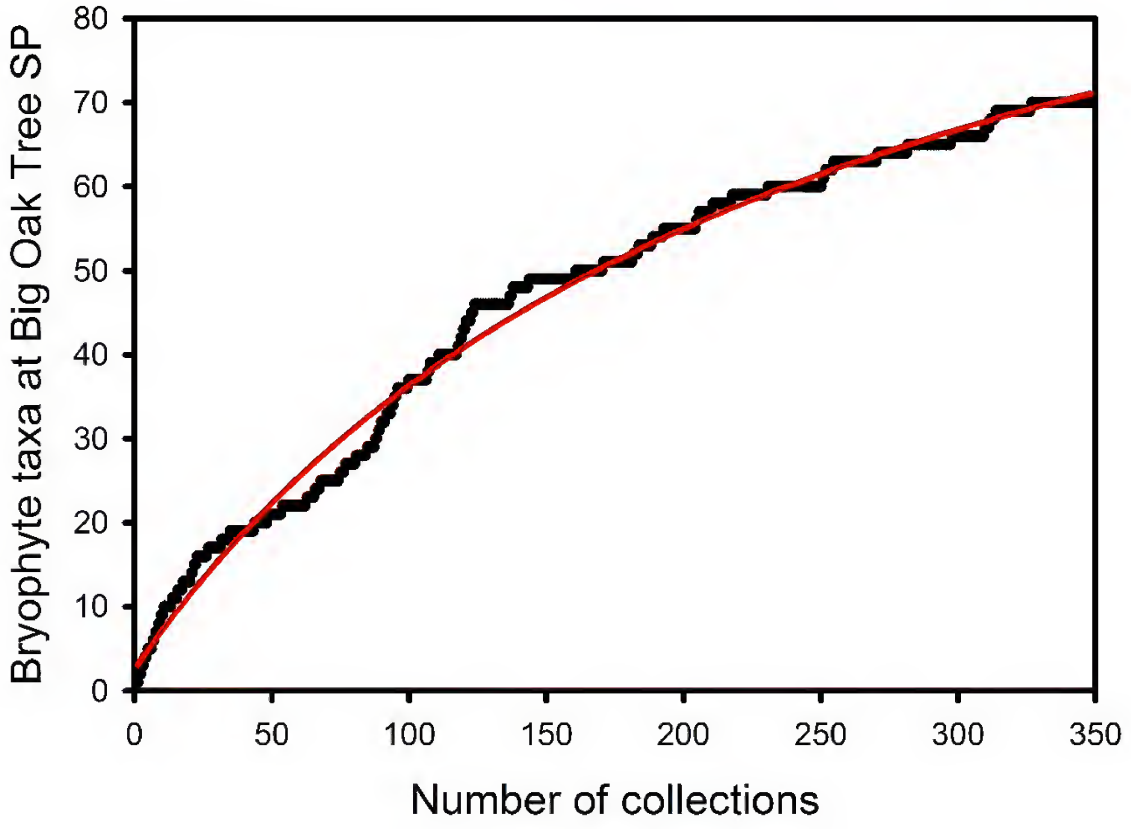

Figure 2. Cumulative number of bryophyte taxa collected at Big Oak Tree State Park and the order in which new taxa were documented during the survey.

Approximately half (34 of 70 species) of the bryophytes collected at Big Oak Tree State Park are new records for Mississippi County. Among these are 13 mosses (*Calliergonella curvifolia*, *Calliergonella lindbergii*, *Dicranum flagellare*, *Dicranum montanum*, *Ephemerum spinulosum*, *Fissidens subbasillaris*, *Gemmabryum klinggraeffii*, *Isopterygium tenerum*, *Ptychostomum pseudotriquetrum*, *Pylaisiadelpha tenuirostris*, *Rosulabryum flaccidum*, *Trematodon longicollis*, and *Weissia muhlenbergiana*) and one hornwort (*Phaeoceros oreganus*) that are newly reported for the Mississippi Lowlands Natural Division in Missouri. Four mosses (*Gemmabryum klinggraeffii* [S1], *Pylaisiadelpha tenuirostris* [S2], *Rosulabryum flaccidum* [S2], and *Trematodon longicollis* [S2]) and the hornwort *Phaeoceros oreganus* (S1) are of conservation concern in Missouri (Missouri Department of Conservation 2017). The discovery of these species at Big Oak Tree State Park adds new information about their habitat and distribution in the state.

Fissidens hallianus is newly documented for Missouri. The species was found growing on the bases of maple trees, as well as on submerged knees and bases of bald cypress (*Taxodium distichum*). *Fissidens hallianus* is otherwise known in eastern North America from Florida,

Illinois, Louisiana, Massachusetts, Mississippi, New Jersey, North Carolina, and Texas (Pursell, 2007). In these states, the species is largely confined to *Taxodium* swamps in the Atlantic and Gulf Coastal Plains. Another Missouri station of *F. hallianus* was found growing on *Taxodium* knees in the Wolf Bayou Unit of Black Island Conservation Area, Pemiscot County (*Holmberg & Atwood 5871*, MO). The combined Missouri stations for this species suggest that, in Missouri, *F. hallianus* is restricted to *Taxodium* swamps in the Mississippi Lowlands Natural Division. However, another Missouri specimen, collected in 2014 but previously unreported (*Brinda 5655*, MO), was made on wet rocks in the Mudlick Mountain Natural Area of Sam A. Baker State Park. This locality is in Wayne County, within the Ozarks Natural Division at the border of the Mississippi Lowlands. Despite the different substrate, the specimen is morphologically similar to the Mississippi County and Pemiscot County specimens. *Fissidens hallianus* is superficially similar to *F. fontanus* in its size, aquatic habitat, and flaccid, long, narrow leaves that become brittle when dry. The two species have likely been confused throughout their range. *Fissidens fontanus* is a relatively common species in slow moving creeks and in stagnant pools throughout the state. Morphologically, the two species differ in the length of their costae, position of their sporophytes, and length of their setae. While *F. hallianus* has a subpercurrent costae that ends 15–35 cells below the leaf apices, the costae of *F. fontanus* is percurrent and terminates 5–15 cells below the leaf apices. Additionally, *F. hallianus* has lateral sporophytes with somewhat short, 0.5–0.6 mm setae. The sporophytes of *F. fontanus* are terminal and have setae that are 0.7–1.5 mm long.

Compared to the number of bryophytes documented from other state parks, the overall bryophyte diversity at Big Oak Tree State Park is relatively low. Eighty-six bryophyte taxa have been reported from Ha Ha Tonka State Park in Camden County (Fuller 1986), 123 bryophyte taxa have been reported from Taum Sauk State Park in Iron and Reynolds counties (Holmberg & Atwood 2014), and 126 bryophyte taxa were reported from Roaring River State Park in Barry County (Hilton 1986). While Big Oak Tree State Park has the smallest acreage of these four parks, the finding of fewer bryophytes is likely the result of the homogenous bryophyte habitat, and a lack of generally different substrates within the park. Rock substrates in the park are scarce and include the man-made cement supports beneath the boardwalk, and the paved asphalt road. The majority of the bryophytes collected during this survey were found on the bases or trunks of trees, as well as on logs. Almost all of the remaining collections were made on soil.

CHECKLIST OF BIG OAK TREE STATE PARK BRYOPHYTES

New records for Mississippi County are indicated with an asterisk (*); a double asterisk (**) indicates a new record for Missouri.

Mosses

Amblystegium serpens (Hedw.) Schimp., on bark of large tree in mown area, *Holmberg & Atwood 5752.*

Anomodon attenuatus (Hedw.) Hübener, on base of large oak, *Atwood & Holmberg 3301*, *3451*; decayed log, *Holmberg 5547.*

Anomodon minor (Hedw.) Lindb., on trunk of oak, *Atwood & Holmberg 3319*, *3442*; on trunk of *Populus deltoidea*, *Holmberg 5610*; on bark of fallen tree, *Holmberg 5510*.

Anomodon triste (Ces.) Sull. & Lesq., on large fallen hackberry, with *Forsstroemia*, *Atwood et al. 3356*

Brachythecium acuminatum (Hedw.) Austin, on rotted log, *Atwood 3387*, *Atwood & Holmberg 3318*, *Atwood et al. 3341*, *Holmberg 5546*, *5606*; on trunk of large fallen tree, *Atwood & Holmberg 3313*; on lower trunk of oak, *Atwood 3431*, *Holmberg 5525*.

**Brachythecium acutum* (Mitt.) Sull., on well-rotted log, *Atwood & Holmberg 3455*; on small decayed limb in association with *Haplocladium sp.*, *Holmberg 5627*.

**Brachythecium laetum* (Brid.) Schimp., on soil in mown lawn, *Atwood & Holmberg 3306*, *Holmberg & Atwood 5861*.

Brachythecium rotaeanum De Not., on decayed log with *Plagiomnium cuspidatum*, Holmberg & *Atwood 5856*, *5859*.

**Bryum argenteum* Hedw., on exposed, gravelly soil, *Atwood & Holmberg 3311*.

**Calliergonella curvifolia* (Hedw.) B. H. Allen, on rotted log, *Atwood & Holmberg 3317*.

**Calliergonella lindbergii* (Mitt.) Hedenäs, on decayed log, *Holmberg 5733*.

Clasmatodon parvulus (Hampe) Sull., on trunk of maple, *Atwood & Holmberg 3450*, *Holmberg & Atwood 5854*; on bark of oak, *Atwood & Holmberg 3331*; common on tree trunk, *Holmberg 5607*; common on *Ulmus sp.* trunk, *Holmberg 5615*.

Climacium americanum Brid., on rotted stump, *Atwood 3379*; on wet soil and well-rotted log, *Atwood & Holmberg 3467*, *Holmberg 5537*; on buttressed base of bald cypress, *Atwood & Holmberg 3416*, *Holmberg 5532*, *5734*.

**Dicranum flagellare* Hedw., on buttressed base of bald cypress, *Atwood & Holmberg 3419*; abundant on large fallen log, *Holmberg & Atwood 5858*.

**Dicranum montanum* Hedw., on buttressed sides of bald cypress, with *Lophocolea*, *Atwood et al. 3352*.

Drummondia prorepens (Hedw.) E. Britton, on fallen burr oak limb in parking lot, *Atwood & Holmberg 3477*.

Entodon cladorrhizans (Hedw.) Müll. Hal., on rotted log, *Atwood 3392*, *Holmberg 5506*, *5520*; on buttressed base of bald cypress, *Atwood & Holmberg 3417*.

Entodon seductrix (Hedw.) Müll. Hal., on base of oak with *Platygyrium*, *Atwood & Holmberg 3304*; on well-rotted log, *Atwood & Holmberg 3464*, *Holmberg 5518*, *5543*; on small decayed branch, *Holmberg 5508*.

Ephemerum crassinervium (Schwägr.) Hampe, sparse in mown lawn area, *Holmberg & Atwood 5750*.

**Ephemerum spinulosum* Bruch & Schimp., on open, bare soil of ditch near road, *Atwood & Holmberg 3303*; on semi-shaded soil, *Atwood & Holmberg 3310*.

**Fissidens bryoides* Hedw., on wet bank along moat surrounding park, *Atwood & Holmberg 3475*.

***Fissidens hallianus* (Sull. & Lesq.) Mitt., on partially submerged knees of bald cypress, *Atwood 3388*, *Atwood & Holmberg 3410*, *Holmberg 5732*; on buttressed base of bald cypress, *Atwood 3390*, *Atwood & Holmberg 3411*; on base of maple, *Atwood 3434*, [Also newly reported for Pemiscot County: Black Island Conservation Area, Wolf Bayou Unit, 6 km southeast of

Stanley, east of parking lot, sparse on bald cypress roots and knees at edge of bayou, *Holmberg & Atwood 5871*; Wayne County: Sam A. Baker State Park, Mudlick Mountain Natural Area, along the Mudlick Hiking Trail, northeast slopes, on wet rock, *Brinda 5655*.]

**Fissidens subbasilaris* Hedw., mixed with *Anomodon*, on base of oak trunk, *Atwood & Holmberg 3316*.

Fissidens taxifolius Hedw., on soil beneath boardwalk observation platform, *Atwood 3366*, *Holmberg & Atwood 5860B*; on well-shaded soil, *Atwood & Holmberg 3329*; on soil of grassy path, *Holmberg 5727*; on decayed log beside water course, *Holmberg 5613*.

Forsstroemia trichomitria (Hedw.) Lindb., mixed with *Anomodon* on tree trunk, *Atwood & Holmberg 3328*; on tree trunk, *Holmberg 5629*; on trunk of oak, 5 ft. from ground, *Atwood & Holmberg 3474*; on large fallen hackberry, *Atwood et al. 3355*.

**Funaria flavicans* Michx., on soil, mown area, *Holmberg 5614*; on soil in gravel parking lot, *Holmberg 5601*.

**Funaria hygrometrica* Hedw., on gravelly soil at parking lot edge, *Holmberg 5552*.

**Gemmabryum caespiticium* (Hedw.) J. R. Spence, on fallen champion burr oak, *Atwood et al. 3347*.

Gemmabryum dichotomum (Hedw.) J. R. Spence & H. P. Ramsay, small patches along road edge, *Holmberg 2917* [This species was not found during this survey but was previously collected at Big Oak Tree State Park in 2009.]

**Gemmabryum klinggraeffii* (Schimp.) J. R. Spence & H. P. Ramsay, sparse in cracks in pavement, *Holmberg & Atwood 5751*.

Haplocladium microphyllum (Hedw.) Broth., on well-rotted log, *Atwood 3430*, *Atwood & Holmberg 3456*, *Holmberg 5523*, *5553*; on soil, mown area, *Holmberg 5600*.

Haplocladium virginianum (Brid.) Broth., on rotted log, *Atwood 3380*, *Holmberg & Atwood 5860C*; on trunk of large fallen tree, *Atwood & Holmberg 3444*.

**Hygroamblystegium varium* var. *varium* (Hedw.) Mönk., on rotted log, *Atwood 3376*, *Holmberg 5611*; on wet soil, *Atwood et al. 3345*, *3354*; on small decayed stick, *Holmberg 5609*, *5626*; on base of hackberry tree, *Holmberg 5628*.

Hygroamblystegium varium var. *humile* (P. Beauv.) Vanderp. & Hedenäs, on wet soil at edge of ephemeral pool, *Atwood & Holmberg 3321*.

**Isopterygium tenerum* (Sw.) Mitt., on well-rotted log, *Atwood et al. 3350*, *Holmberg 5736*.

Leptodictyum riparium (Hedw.) Warnst., on rotted log, *Atwood 3371*, *Atwood & Holmberg 3322*, *Atwood et al. 3357*, *3363*, *Holmberg 5531*, *5608*, *5726*; on partially submerged knees of bald cypress, *Atwood 3395*.

Leskea australis Sharp, on buttressed base of bald cypress, *Atwood & Holmberg 3457*; on base of oak, *Atwood & Holmberg 3468*, *3471*; on expanded base of large cottonwood, *Holmberg 5519*; on 3 in. dia. *Vitis sp.* trunk on ground, *Holmberg 5524*; patch on base of small trunk, *Holmberg & Atwood 5850*.

Leskea gracilescens Hedw., on base of large bald cypress, *Atwood & Holmberg 3325*; on cypress knee, *Atwood & Holmberg 3463*; on buttressed oak, *Atwood & Holmberg 3449*, *Atwood et al. 3343*; common on decayed log, *Holmberg 5725*; on patch on edge of asphalt pavement,

Holmberg & Atwood 5865; on large sycamore trunk, *Holmberg 5508B*; on base of large tree in open area, *Holmberg 5598*.

Leucodon julaceus (Hedw.) Sull., on fallen bark from large oak tree, *Atwood & Holmberg 3460*; on bark of fallen hackberry, *Atwood et al. 3346*; on bark of fallen tree, *Holmberg 5514*; small patches on edge of asphalt pavement, *Holmberg & Atwood 5863*.

Orthotrichum diaphanum Brid., on base of large sugarberry tree, *Holmberg 2910*. [This species had previously been collected at Big Oak Tree State Park but was not found during the current park survey. The specimen is very sparse and the species is rare in Missouri (S2).]

Orthotrichum ohioense Sull. & Lesq., on fallen upper limb of cottonwood tree, *Holmberg 5549*.

Orthotrichum pumilum Sw., on bark of large fallen tree limb, *Atwood & Holmberg 3461*; on knot-hole of decayed log, *Holmberg & Atwood 5855*; small patches on edge of asphalt pavement, *Holmberg & Atwood 5864*.

**Orthotrichum pusillum* Mitt., on fallen elm trunk, from 30 ft up, *Holmberg 5517*.

**Physcomitrella patens* (Hedw.) Bruch & Schimp., on cracking mud of dry lakebed, *Atwood & Holmberg 3405*, *3406*, *3408*, *Holmberg 5728*; on top of large bald cypress stump in dry lake bed, normally under water, *Holmberg 5729*.

Physcomitrium pyriforme (Hedw.) Hampe, on exposed soil in picnic area, *Atwood & Holmberg 3307*, *Holmberg 5599*; on wet bank along moat surrounding park, *Atwood & Holmberg 3476*.

Plagiomnium cuspidatum (Hedw.) T. J. Kop., on rotted log, *Atwood 3375*, *Atwood & Holmberg 3454*, *Atwood et al. 3359*, *Holmberg 5536*, *5612*, *Holmberg & Atwood 5860*; on soil in picnic area. *Atwood & Holmberg 3305*.

Platygyrium repens (Brid.) Schimp., on large, fallen branch, *Atwood 3432*; on bark of fallen tree, *Holmberg 5512*.

**Pleuridium subulatum* (Hedw.) Rabenh., on soil below boardwalk observation platform, *Atwood et al. 3340*.

Ptychomitrium drummondii (Wilson) Sull., on fallen tree limb, *Atwood 3370*; on trunk of bald cypress, *Atwood 3377*; on base of large elm, *Atwood & Holmberg 3302*; on fallen tree bark from large oak, *Atwood & Holmberg 3466*; abundant on 30 in. dbh bald cypress trunk, *Holmberg 5544*; on lower trunk of large fallen tree, *Holmberg 5528*; small patches on edge of asphalt pavement, *Holmberg & Atwood 5862*.

**Ptychostomum pseudotriquetrum* (Hedw.) J. R. Spence & H. P. Ramsay *ex* Holyoak & N. Pedersen, on decayed log, *Holmberg 5605*.

**Pylaisiadelpha tenuirostris* (Bruch & Schimp. *ex* Sull.) W. R. Buck, on rotted log, *Atwood 3382*, *Atwood & Holmberg 3446*, *3472*, *Holmberg 5604*; on trunk of bald cypress, *Atwood 3394*, *Atwood & Holmberg 3447*, *Atwood et al. 3353*, *Holmberg 5735*, *Holmberg &Atwood 5852*.

**Rhynchostegium serrulatum* (Hedw.) A. Jaeger, on rotted log, *Atwood & Holmberg 3314*, *Holmberg 5625*.

**Rosulabryum flaccidum* (Brid.) J. R. Spence, on rotted stump, *Atwood 3381*; on side of bald cypress trunk, *Holmberg & Atwood 5730*.

**Rosulabryum laevifilum* (Syed) Ochyra, on trunk of bald cypress, 6 ft. from ground, *Atwood & Holmberg 3412*; on soil in gravel parking lot, *Holmberg 5602*.

**Schistidium viride* H. H. Blom & Darigo, on cement support beneath boardwalk, *Atwood & Holmberg 3480*.

Sematophyllum adnatum (Michx.) E. Britton, on well-rotted log, *Atwood & Holmberg 3413*, *Atwood et al. 3362*.

Syntrichia pagorum (Milde) J. J. Amann, on bark of large fallen tree limb, *Atwood & Holmberg 3462*; on fallen upper limb of cottonwood tree, *Holmberg 5551*.

**Thuidium delicatulum* (Hedw.) Schimp., sparse, on rotted log, *Atwood 3374*, *Holmberg 5526*.

**Tortella humilis* (Hedw.) Jenn., on cement support beneath boardwalk, *Atwood & Holmberg 3482*; on fallen champion burr oak, *Atwood et al. 3348*.

**Trematodon longicollis* Michx., under boardwalk observation platform, *Atwood 3367*, *Holmberg 5633*.

**Weissia controversa* Hedw., on soil, road on berm around lake, *Holmberg 5616*.

**Weissia muhlenbergiana* (Sw.) W. D. Reese & B. A. E. Lemmon, on soil in mown area, *Atwood & Holmberg 3309*, *3479*, *Holmberg & Atwood 5753*; on gravelly soil along road, *Holmberg 5603*; on soil, at base of wooded berm, *Holmberg 5731*.

Liverworts & Hornworts

Aneura pinguis (L.) Dumort., on well-rotted log, *Atwood 3369*, *3373*, *Atwood & Holmberg 3320*, *3414*, *3473*, *Atwood et al. 3361*; *Gier 3905* (NY); *Holmberg 5535*, *5538*, *5541*. [Gier (1955) reported *Pallavicinia lyellii* (Hook.) Carruth. from Mississippi County based on specimens from Big Oak Tree State Park. Re-examination of these specimens, deposited at NY, found them to be misdeterminations of *A. pinguis*.]

Chiloscyphus pallescens (Ehrh. *ex* Hoffm.) Dumort., on well-rotted log, *Atwood et al. 3349*.

Frullania eboracensis subsp. *eboracensis* Gottsche, on bark of burr oak, *Atwood 1532*; on elm trunk, *Holmberg 2915*.

**Frullania eboracensis* subsp. *virginica* (Lehm.) R. M. Schust., on trunk of oak, *Atwood & Holmberg 3443*.

**Frullania ericoides* (Nees) Mont., on bark of fallen tree, *Holmberg 5513*.

Frullania inflata Gottsche, on bald cypress trunk, *Atwood 3378*, *Atwood & Holmberg 3327*, *3448*, *Holmberg 5545*; on bald cypress log in marshy bottomland woods, *Holmberg 5631*; on upper trunk of recently fallen tree, *Atwood & Holmberg 3326*, *Holmberg 5522*; on bark of log, *Atwood & Holmberg 3459*; on trunk of large fallen oak, *Atwood 3433*; on trunk of oak, *Atwood 3435*, *Atwood & Holmberg 3300*; on maple, *Atwood 3436*; on hackberry trunk, *Holmberg 5507*, *5523b*; many patches on shrub trunk in standing water, *Holmberg 5540*; on silver maple trunk, *Holmberg & Atwood 5851*; on American elm, 6 in. dbh, *Holmberg 5509*.

Lophocolea heterophylla (Schrad.) Dumort., on buttressed base of bald cypress, *Atwood 3383*, *Atwood et al. 3344*, *3360*, *Holmberg & Atwood 5632*, *5853*; on well-rotted log, *Atwood 3372*, *3385*, *Atwood & Holmberg 3418*, *3421*, *3445*, *3469*, *Atwood et al. 3351*, *Holmberg 5534*; on base of elm, *Atwood & Holmberg 3323*; on fallen 4 in. limb, *Holmberg 5630*.

Notothylas orbicularis (Schwein.) Sull., [This species was reported from the park by Doolen (1984) based on a specimen, *Doolen 801-B*, that was verified by Raymond Stotler† (Wanda Doolen, personal communication, 2017); the specimen could not be located.]

**Phaeoceros oreganus* (Austin) Hässel, on soil below boardwalk observation platform, *Atwood 3368*.

Porella pinnata L., on wet trunk base of oak, *Atwood 3393*, *Atwood & Holmberg 3415*, *3453*; on base of large bald cypress, *Atwood & Holmberg 3324*; on exposed roots of tree, *Atwood et al. 3342*; on base of maple, *Atwood 3437*; on standing dead *Ilex* trunk, 4 in dbh, *Holmberg 5542*.

Ricciocarpos natans (L.) Corda, floating near shoreline of pond, *Atwood & Holmberg 3330*; on cracking mud of dry lakebed, *Atwood & Holmberg 3407*, *Holmberg 5521*.

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Cuscuta obtusiflora var. *glandulosa* belatedly confirmed for the flora of Missouri

AARON FLODEN[1] AND ALAN E. BRANT[2]

ABSTRACT. — *Cuscuta obtusiflora* Kunth var. *glandulosa* Engelm. is reported as new to the flora of Missouri, where it has been documented from three counties. A revised key to the species of *Cuscuta* in the state is provided.

Dodders (*Cuscuta* L., Convolvulaceae) are parasitic twining herbs that occur on various woody and herbaceous hosts throughout Missouri and previously included 9 native and one introduced species (Yatskievych 2006). The taxonomic difficulties of the genus are well-known due to often difficult and cryptic specific characters and that many of the morphological characters are limited to the inflorescences and flowers (Yatskievych 2006, Yuncker 1932). It is these problems with accurate determination or unclear species boundaries that have likely led to the exclusion of *Cuscuta obtusiflora* Kunth var. *glandulosa* Engelm. from the flora despite having been collected first in Missouri in 1929 (see specimens examined).

Costea et al. (2006) did not report *Cuscuta obtusiflora* var. *glandulosa* for Missouri in their revision of the Pentagona complex, which was published concurrently with the Flora of Missouri *Cuscuta* treatment (Yatskievych 2006). In 2007, several collections at MO were annotated by M. Costea as this species. The inclusion of this species in the Missouri flora was further delayed because few of the *Cuscuta* collections at MO are databased. A single specimen in the Tropicos database (http://www.tropicos.org) was observed by Alan Brant with an annotation of *C. obtusiflora* var. *glandulosa*, which had not previously been reported for the flora. Further searching by Aaron Floden revealed additional collections annotated as such. Here we provide the voucher information documenting this species for the Missouri flora; we also provide an updated key to the genus in the state to aid field studies.

Cuscuta obtusiflora var. *glandulosa* differs from other subsessile flowered-species without a stylopodium in that the flowers are 5-merous vs. 3–4-merous in *C. cephalanthi* Engelm. and *C. polygonorum* Engelm. *Cuscuta obtusiflora* has typically been determined as *C. polygonorum* in the past for the Missouri flora because of similarly globular inflorescences and acute perianth parts in both species.

The distribution of *Cuscuta obtusiflora* var. *glandulosa* in Missouri covers several regions although it has been documented from only three Missouri counties; one in the Ozark

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Border in Gasconade County in the Lower Missouri subsection, and two in the Ozarks including Greene County on the Springfield Plateau subsection and St. Francois County in the St. Francois Mountains subsection. Given its wide range of hosts (Costea et al. 2006, and see below) and its current known distribution, it should be looked for in the intervening counties in similar habitats where potential host species are also present. Hosts not reported by Costea et al. (2006) on which the plant has been reported in Missouri are *Cephalanthus occidentalis* and *Justicia americana*.

Specimens examined: **U.S.A. MISSOURI:** GASCONADE CO.: south bank of Bourbeuse river just east of gravel road crossing (ca. 8 mi. SSE of Owensville), locally frequent on *Cephalanthus occidentalis*; spreading to *Polygonum lapathifolium* but barely surviving there; NE 1/4 SE1/4 sec. 6 T40N, R5W; 30 Aug 1986, *R. Gereau & D. Hannon 2293* (MO) (as *C. polygonorum*). GREENE CO.: along James River, ca. 3 km S of Springfield, wooded stream valley and narrow floodplain; loamy alluvium, cherty-limestone outcrops; common on *Justicia americana* on gravel bars; center of sec. 27 T28N R22W; 5 July 1975, *R.W. Sanders 75011* (MO). ST. FRANCOIS CO.: Doe Run, along St. Francis River, 28 July 1929, *J. Kellogg 25782* (MO); 0.9 miles south of State Highway B; sandy alluvium along the St. Francis River, open; on *Justicia americana* at stream margin; SW1/4 sec. 6 T35N, R5E; 3 August 1986, *A. Brant, B. Allen, P. Gomez A., B. Clemens & D. Hannon 962* (MO).

Updated Key to Missouri Cuscuta

Key adapted from Yatskievych (2006), Costea at al. (2006), and Weakley (2015). The stylopodium in some species is a thickened ridge at the style base.

1 Flower subtended by 2–10 imbricate bracts; sepals deeply divided nearly to the base.
  2 Flowers pedicillate, in paniculate clusters; bracts orbicular to ovate, apices obtuse..... ***C. cuspidata***
  2 Flowers sessile, in dense clusters along the stem; bracts and apices various.
    3 Bracts oval to orbicular, appressed and imbricate, apices rounded; styles not exserted in flower, exserted 1.5–1.8 mm long in fruit ..... ***C. compacta***
    3 Bracts lanceolate to oblanceolate, spreading to recurved, apices acuminate; styles exserted 2.5–3.5 mm long in flower and fruit..... ***C. glomerata***
1 Flowers ebracteate (occasionally with 1 bract at base of pedicel); sepals divided 1/3–1/2 of their lengths.
  4 Perianth surface with dense, minute papillae (granulate); corolla lobes acute and pointed inward.
    5 Calyces and corollas mostly 4-lobed; infrastaminal scales not reaching filament bases, reduced to 2 narrow, toothed, lobes of tissue..... ***C. coryli***
    5 Calyces and corollas mostly 5-lobed; infrastaminal scales reaching filament bases, well developed and fringed along the margins ..... ***C. indecora***

4 Perianth surface not papillose; corolla lobes acute to obtuse and erect, spreading, or recurved.
6 Stylopodium present; flowers 5-merous ..... ***C. gronovii***
6 Stylopodium absent; flowers 3–4-merous or 5-merous.
7 Flowers subsessile, inflorescences globular.
8 Perianth 5-merous ..... ***C. obtusiflora*** var. ***glandulosa***
8 Calyces and corollas typically 3- or 4-merous.
9 Corolla lobes rounded or obtuse; corolla tube much longer than the calyx and extending past calyx lobes ..... ***C. cephalanthi***
9 Corolla lobes acute; corolla tube subequal to the calyx lobes, but not longer than them ..... ***C. polygonorum***
7 Flowers pedicellate, pedicels subequal to perianth, inflorescences loose.
10 Calyx lobes strongly overlappping and forming angles at sinus where these project outward, thus appearing 5-angled; lobes of the corolla 1.5–2.5 mm long ..... ***C. pentagona***
10 Calyx lobes not overlapping at base, thus not appearing strongly angled; lobes of the corolla 1.5–3 mm long ..... ***C. campestris***

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Thelypteris noveboracensis (New York fern) new to Missouri from the Southeastern Missouri Ozarks

ALAN E. BRANT[1]

ABSTRACT. — *Thelypteris noveboracensis* (=*Parathelypteris noveboracensis*) is reported new for Missouri from wetlands in Wayne County, in the southeastern Missouri Ozarks.

Thelypteris noveboracensis (L.) Nieuwland (Thelypteridaceae; =*Parathelypteris noveboracensis* (L.) Ching) is a common terrestrial fern of eastern North America from Alabama and Mississippi into Canada, reaching its northern limits in Newfoundland. Arkansas, Oklahoma, and Illinois are on the western fringes of its range. According to Yatskievych (1999), it "may eventually be found growing in Missouri."

In September 2018, while the author was revisiting a Missouri Natural Features Inventory potential natural features site (Wayne County PNFS No. 63), a population of New York fern was discovered. The site is a privately-owned stream-head seep-fen complex located around the junction of Little Creek and Dunaway Hollow. The area is currently partially impacted by grazing. Other rare species (Missouri Department of Conservation 2018) documented during the revisits to this complex are *Saccharum giganteum* (Walter) Persoon and *Platanthera clavellata* (Michaux) Luer. Other associates include *Juncus subcaudatus* (Engelm.) Coville, *Pedicularis lanceolata* Michx., *Phlox glaberrima* L. subsp. *interior* (Wherry) Wherry, *Rudbeckia fulgida* Aiton var. *fulgida*, and *Salix sericea* Marshall.

Two species of *Thelypteris* are now known from Missouri — *Thelypteris noveboracensis* and *Thelypteris palustris* Schott var. *pubescens* (Lawson) Fernald. The name *Parathelypteris noveboracensis* has recently been applied to New York fern (e.g. Kartesz 2015). The two species are easily separated: *T. noveboracensis* has fronds tapered at both ends (Strausbaugh and Core 1977), with the proximal pinnae greatly reduced (Figure 1), while in *T. palustris* var. *pubescens* the fronds are deltoid and the proximal pinnae are not reduced or only slightly so (Smith 1993). Both species form colonies and have have thin, 1-3 mm diameter creeping dark rhizomes and generally occur in wet soils.

> *Voucher specimen*: **U.S.A. Missouri:** WAYNE CO.: Acid seep near mouth of Dunaway Hollow above Little Creek; open and partial shade, saturated soil; 14 September 2018, 37.29572^{0}N, 90.29644^{0}W, *Brant 8934* (MO).

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New York fern should be considered for State Listing as a species of conservation concern (SOCC) in Missouri as S1 since it is currently known from a single Missouri location.

Figure 1. *Thelypteris noveboracensis,* Wayne Co., Missouri, showing fronds tapering at both ends and reduced proximal pinnae (*Brant 8934*).

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Bee Power

BOOK REVIEW

Our Native Bees – North America's Endangered Pollinators and the Fight to Save Them, by Paige Embry. 2018. Timber Press, Portland OR. 224 pp.
[ISBN 9781604697698 (hardcover); ISBN 9781604698411 (e-book)]

Reviewed by:
MIKE ARDUSER[1]

Bees have dominated the front pages of insect news for the past decade, headlining stories that often simmer with doom and gloom, inspiring hand-wringing about an impending bee apocalypse. Should we worry?

In this book, an epiphany involving tomato pollination springboards author, veteran gardener and self-confessed bee novice Paige Embry into the world of North American bees and what they mean to us. Her style is personal and inviting, and we willingly take the journey with her. Along the way we get to know a host of "bee people": those working with bees in agriculture and research, and those working with bees simply because they love them. The author explores several "big questions" about bees direct from the headlines, bringing in many current or recent bee research projects, tying their results to broader bee issues, provides references for each chapter and a Further Reading section as well as a list of relevant websites. Though clearly not a field guide to bees, there are ninety-one splendid to spectacular color photographs of various bee species, ably demonstrating their diversity; most images are accompanied by a brief explanatory text box.

After a very brief introduction to pollination and bees, the book begins not with native bees as the title might suggest, but with a chapter on the European honey bee, the six-legged workhorse of modern agriculture. The chapter serves as a framework for the first half of the book, and the following four chapters explore the agricultural importance, potential, and management of our native bees, including bumblebees, the blue orchard bee (*Osmia lignaria*), and others, as well as some of the problems they face (e.g., pesticides, diseases). The recent Federal listing as Endangered of the rusty-patched bumblebee (*Bombus affinis*), once very common in much of the eastern US, happened after the completion of the book, and so isn't discussed. However, the probable extinction of a related species, Franklin's bumblebee (*Bombus franklini*), and the likelihood of a similar cause of decline between the two species (and several other species) is

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brought out in some detail. There is a chapter on cleptoparasitic bees (cuckoo or cowbird bees), and the remaining chapters address what the general public can do – and is doing – to conserve native bees from golf courses to backyards and lawns.

Given the book's title, I expected a portion of it, a chapter at least, dedicated to an overview of the status of our native bees, but there are only two pages about the "state of bees in the wild." The book also suffers a bit from the lack of any serious discussion about the critical importance of bees to rare and endangered plants, or to natural communities in general. The extensive literature on pollination ecology could have been mined for numerous examples.

Several other important issues regarding native bees are treated lightly or not at all: introduced bees, including non-native Africanized bees, are barely mentioned. Given the exponential increase in the number of introduced species in the past two decades, the explosive near-nationwide spread of certain introduced megachilids (*Osmia cornifrons, O. taurus, Megachile sculpturalis, Anthidium manicatum*), and the steady northward march of Africanized bees into the southern United States, a chapter on exotics and their potential ecological impacts (and their potential value, in the opinion of some agricultural interests) would have been useful. Indeed, the two *Osmia* species mentioned above appear to be displacing native *Osmia* species, including the blue orchard bee, in much of the eastern US, and many urban bee surveys in the eastern US (including a recent survey in St. Louis) document the numerical dominance of exotic bees in cities.

Despite these criticisms, this is first and foremost a book about the interdependence between people and bees, and that is its strength. It should be read with that in mind. If you haven't yet embraced the power of bees and the urgency of conserving them, this book will convince you.

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Smarter Than We Think?

BOOK REVIEW

The Revolutionary Genius of Plants, by Stefano Mancuso. 2018 (English translation; original copyright 2017). Atria Books, New York. 240 pp.
[ISBN 9781501187858 (cloth)]

Reviewed by:
DOUGLAS LADD[1]

Subtitled *A new understanding of plant intelligence and behavior*, by a professor at Italy's University of Florence billed as the "world's leading plant neurobiologist," this book challenges the reader's assumptions and provides a well-grounded case for why humans have consistently underrated the ecological sophistication, adaptability, survival mechanisms, and sensory and memory capacity of plants.

Despite comprising more than 80% of the Earth's living biomass, plants have been under-explored by humans, and mostly from a utilitarian perspective; hence the 2,000+ new species of flowering plants still being described new to science each year, including 50-meter-tall trees. We tend to interpret plants through an animal-centric prism, and this same paradigm has suffused much of human knowledge, resulting in largely centralized structures and models in everything from engineering to delivery of services. Unlike animals, which mostly depend on mobility, survival of sessile organisms such as plants requires complex and adaptive decentralized mechanisms.

Here, in nine enjoyable chapters with catchy titles like "Memories without a Brain" and "Green Democracies," the author pleads for a more nuanced understanding of plants and makes the case that "plants have already provided the best solutions for most of the problems that afflict humanity." The author considers it no accident that some of the most successful human constructs, such as the internet, are modelled after the diffuse hierarchical organization of plants. The text is enhanced by numerous excellent and intriguing color images and photographs, including dramatic two-page spreads opening each chapter. It is a testimony to the quality of the translation that this work reads as if it was originally written in English.

The central tenet of the first half of the book is that plants have evolved survival strategies, including sophisticated sensory capabilities, inter- and intra-organism communications, and memory capacity. These systems are almost unrecognizable through the perceptual lens of animal-

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based biology, and in many cases are more innovative, flexible, and cooperative than in animal systems. While initially surprising, this should not come as a shock given that we have long known that, from a biochemical perspective, plants are far more complex, capable, and sophisticated than are animals.

Despite lacking brains and nerves, plants can sense and react to subtle environmental variables along multiple gradients, and in many cases can communicate information about these conditions both within the plant and to other individuals. A key thesis of this work, of which I was initially highly skeptical, is that plants have a clearly documented capacity for memory. While these are not the neutrally imprinted memories associated with animals and their centralized brains, the author makes a compelling, documented case for the transfer and storage of information about environmental stimuli in plants through time. There are fascinating examples, including the ability of sensitive plant (the Neotropical *Mimosa pudica*, famed for its rapid leaf movement when touched) to 'learn' not to react to harmless stimuli while still reacting to novel stimuli. Astoundingly, the plants can remember these differences for 40 days despite lacking traditional memory storage apparatus. It turns out that Charles Darwin and his son wrote separate accounts about plant intelligence, Darwin senior noting that plants have capabilities "like the brains of lower animals"!

The author speculates on the conceptual and linguistic convolutions scientists have used since the 1700s to discuss these long-known phenomena without invoking the word 'memory' (acclimatization, priming, conditioning, etc.). These accounts lead to an insightful glimpse into the role of epigenetic mechanisms, including DNA methylation, in plant memory, all clearly explained and illustrated.

One of two shockers in the book is a discussion of how a South American liana (*Boquila trifoliata*) adapts its leaves to resemble the leaves of the plant on which it grows, with a single plant on multiple neighboring species sometimes displaying multiple leaf morphologies, each evocative of its nearest neighbor! (!!). This leads to an account of evolutionary drivers and potential mechanisms, culminating in a discussion of potential optical-sensing properties of plants, linking to long-forgotten British research proving the ability of some plant cells to moderate and focus images of their surroundings. Although still an unproven hypothesis: wow. [The other shocker in the book concerns the amazing ability of some plants to tune their extrafloral nectaries to first attract target insects, then to chemically adjust the nectar to biochemically enslave and weaponize the insects, with speculation on a similar example involving humans.]

The book includes many riveting examples of earlier researchers and their discoveries, some of which went unnoticed for centuries before being resurrected as research topics in recent years. Along the way, it is impossible not to absorb a panoply of interesting anecdotes and tidbits: →Prions may play a role in plant memory! →Galileo didn't invent the telescope! →The telegraph plant, an Asian shrub, moves continuously! →Fall colors in deciduous trees are likely a boast to insects! →A single rye plant can have more than 100 million root apices! →The architecture of

London's Crystal Palace was derived from the structure of the giant water lily! →There is a special hot sauce that sells for thousands of dollars for a few milliliters! ...and so on. Not many books include passages linking Athenian democracy, collective decision making among social insects, jury theorem, and patterns of plant growth and development, but this work successfully unifies them.

There are vividly clear and detailed explanations of the complex and often overlooked structures and mechanisms plants have for everything from timing seed dispersal to planting themselves at the correct soil depth, and for adapting to being at a fixed location subject to predation and changing conditions ("animals try to avoid problems, plants solve them"). The signaling and sensing network of a root system, a brain-like neural network capable of assimilating and signaling vast quantities of real-time information, is convincingly posited as equivalent to the collective intelligence and behavioral adaptations of some social animals. It turns out that plant root system development may prove to be the best model for developing extraterrestrial exploration mechanisms, and can be effectively modelled using swarm behavior algorithms.

The final two chapters of the book are to me the least interesting and somewhat discordant from the rest of the text. These cover bioinspiration (=biologically inspired design; hardly a new field, as demonstrated even by examples in the book's previous chapters) and the author's current research and its extraterrestrial applications, including a detailed account of research on weightlessness in plants, and an overly self-focused account of the author's multiple zero-gravity simulator flights; these distracted from the overall impact and power of the rest of the book. There is a succinct bibliography of sources by chapter, with a preponderance of material from highly regarded, peer-reviewed journals.

Overall this is an enjoyable, informative, and even at times inspiring read that caused me to rethink some of my preconceptions after more than 40 years as a practicing botanist. If I have any criticisms, it is that at times the book does not adequately consider contemporary evolutionary theory, instead sometimes attempting to create an aura of mystery and imputed sentience. As mentioned previously, there are also lots of diversions – Soviet agricultural history, the history of the race to be the first to induce flowering in giant water lilies, etc. Readers will either find these fascinating or tedious and distracting, but to me they enhanced and anchored the themes of the book and I eagerly encountered each branching exploration like a shaman welcomes entheogens. In this case, I highly recommend the trip.